SCIENCE ABSTRACTS.

Section A.—PHYSICS.

AUGUST 1918.

GENERAL PHYSICS.

816. *The Law of Error.* **F. Y. Edgeworth.** (Phil. Mag. 35. pp. 422-431, May, 1918.)—R. A. Sampson in a paper "On the Law of Distribution of Errors," read before the International Congress of Mathematicians, 1912 (vol. ii, p. 163 *et seq.*) disputes the validity of the law of error. He finds, for instance, that the law is not perfectly fulfilled by many astronomical observations which have been made with the greatest care. The statistician, however, grounds his expectation of the law on numerous independent causes. Where that condition is imperfectly fulfilled we do not expect the law of error to be realised perfectly. In the molecular theory, on the other hand, we should expect practically perfect fulfilment of the law. In Sampson's criticism of Poisson's proof he is right in pointing out that the independence postulated is not sufficient by itself and without any additional conditions to secure the fulfilment of the law of error. It is necessary to add, however, that commonly and practically such additional conditions are present. A. R.

817. *Definition of Hardness.* **W. C. Unwin.** (Engineering, 105. p. 535, May 17, 1918.)—For sixty years some form of indentation test has been used for discriminating hardness. In France a monkey or hammer, faced with a hard-steel pyramidal or conical point, was dropped from a known height on the specimen. The reciprocal of the width of the impression was taken to measure the hardness. The present article recalls that Martel communicated two papers to the Paris Congress on Testing Materials in 1895 and 1900 dealing with the testing of hardness by the falling-monkey method. He showed that the work expended in indentation is proportional to the volume of the indentation. The identity of Martel's and Brinell's hardness numbers is now pointed out. **F. Buckingham.** (*Ibid.* pp. 632-633, June 7, 1918.)—Buckingham points out that the demonstration of the identity of the Martel and Brinell hardness numbers is valid only if an approximation is made which a more exact treatment shows to be inadmissible. If, however, the Brinell hardness number be obtained by dividing the applied load by the circular area of the indentation instead of by the area of the spherical calotte, then its identity with the Martel number would be complete. C. O. B.

818. *Failure of Short Tubular Struts of High-tensile Steel.* **W. C. Popplewell and H. Carrington.** (Inst. Civ. Eng., Proc. 203. pp. 381-398, 1916-

1917.)—An investigation of the strength of steel tubes used for aeroplane construction. The material employed was a nickel-chromium steel containing 0·2 to 0·3 % C, 4 to 5 % Ni, and 1 to 1·5 % Cr. Tubes were tested of various gauges and both in the annealed and hard conditions. It was found that where t is the thickness and r the radius of the tube there is a definite crinkling stress which, in the case of the annealed tubes varies, approximately, with t/r so long as this does not exceed 0·1. For values of t/r greater than this the elastic breakdown is identical with the elastic limit of the material. These results seem to confirm the theoretical conclusions of W. H. Barling and his experimental results for mild steel tubes. It is concluded that for tubular struts of the hard material tested, special attention is necessary when t/r is greater than 0·1, whereas in annealed tubes this caution is needful when t/r is less than this. The wave-lengths as measured on the specimens were from 80 to 100 % longer than those given by the theoretical formulæ of Southwell and Lilley. The difference in the crinkling stress between a tube of exact geometrical form, and an actual tube seems to be due chiefly to a slight deviation from this form in the first instance, and for an appreciable increase in the deviation greater than this, the crinkling stress remains sensibly constant. J. W. T. W.

819. *Stresses.* **R. F. Gwyther.** (Phil. Mag. 35. pp. 490–492, June, 1918.)—It is intended to provide a reasoned basis for a theory of stresses, applicable in the first case to a body which satisfies the geometrical conditions for acting as a rigid body, but which shall be capable of extension to elastic bodies or to other approximations to natural bodies, without introducing the assumption of an "undisturbed" condition in which the body is free from stress. The doctrine, for the development of which the different stages are indicated below, is the outcome of a series of papers on the "Specification of Stress" [Abs. 1628 (1912), 1661 (1914)]. (1) The nine elements of mechanical stress obey well-known laws of resolution. By introducing the notion of infinitesimal rotations of the coordinate axes about their own positions, we can, for the present purpose, replace these relations by the three differential operators, acting upon the elements of stress, the determination of which follows from the laws of their resolution ; *i.e.* these operators are based on mechanical considerations. (2) If we now consider any arbitrary vector (a virtual or potential displacement), we may look upon the nine first differential coefficients of its components as being replaced by the nine elements of virtual or potential strain (including among them the three rotations). These nine virtual strains may now be affected by the same infinitesimal rotation of the axes as in (1), and the three consequent differential operators acting upon the elements of strain may be deduced, in this case on geometrical grounds. The forms of the two sets of operators are similar, and may easily be made identical. (3) The fundamental assumption, on which the theory is based, is now introduced, namely, that the elements of a material stress are functions of the first differential coefficients of the components of some vector quantity, *i.e.* functions of some set of nine virtual strains. (4) Turning now to the two sets of differential operators concerning elements of stress and of virtual strain, we are able, in consequence of assumption (3), to express each element of stress in terms of the nine elements of virtual strain ; or, conversely, each element of strain in terms of the nine elements of stress, by means of sets of simple partial differential equations. In obtaining these solutions constants will be regarded as uniform and isotropic, and consequently the possibility of a crystalline structure is

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excluded. The body is also supposed not to be in a state of constraint, and, further, the solutions are limited to relations of a linear form. From this it follows that the relations between the elements of stress and of virtual strain agree in form with the corresponding relations of the theory of elasticity. (5) Supposing the elements of virtual strain to be expressed in terms of the elements of stress, we may eliminate the former by differentiation, and obtain a set of relations involving only the elements of stress (stress-relations). (6) The set of three mechanical stress-equations which correspond to the state of rest or motion of the body as a rigid body are now introduced. With these equations are combined the stress-relations of (5). From this combination we may obtain stress-equations, by which we may regard the elements of stress to be defined, as far as they are capable of being defined, so long as the surface-traction conditions have not been considered. (7) Up to this point such cases as a cube of metal on a rough inclined plane, or a connecting-rod moving in a prescribed manner, have been contemplated, the geometrical conditions for rigidity being preserved. The stresses are not to be regarded as undefined, but as being determinate. (8) The theory of elasticity is next introduced by the definition of an elastic body as a body such that the strain, hitherto considered as a virtual or potential strain, is the actual strain experienced by the parts of the body. The stresses being definite, the strains become definite, and the displacement may be deduced.

The acceptance of the principles involved in this doctrine would have the effect of making the subject of stresses an integral part of the statics and dynamics of a rigid body. Apart from the introduction of the cases of motion of the body, this would appear, at first sight, merely a matter of exposition of the elastic theory. But a further consequence would be that the determination of the elastic strains from the rigid body stresses would be only the first stage in the theory of elasticity. A closer approximation to the values of the stresses would follow from the estimated alteration of the surface-traction conditions consequent on the displaced condition of the surface of the body, and the subject would become one of continued approximations on the lines of certain other subjects of mathematical physics, and an opportunity would be provided for a theory of permanent set and of rupture.

A. W.

820. *On the Extension of Riemann's Hypothesis.* **R. Malmström.** (Öfversigt af Finska Vetenskapssoc. Forhändl. No. 6, 1917–18. Phys. Zeits. 19. pp. 153–156, April 15, 1918. Extract.)—The present paper describes an attempt to extend Riemann's hypothesis, while retaining relative velocity, so that when applied to Kaufmann and Bucherer's data the same result is given as on the theory of Lorentz [Abs. 684 (1918)]. This extension may be effected either by replacing the expression $(1 + u^2/2c^2)$ by another function of $u^2/2c^2$, where u is the relative velocity of two electrons, and retaining the Hamiltonian Principle, or, in analogy with Ritz, by multiplying the separate terms of the expression deduced from the Hamiltonian Principle by functions of the relative velocity. By the first procedure complications arose due to terms being obtained when differentiating according to the time, which, in the case of electronic motion in electrical and magnetic fields, contain the potential of the static electricity, and the components of the vector potential of the electric current, multiplied by the velocity and acceleration components of the electrons and their products. The second method has, in consequence, been chosen by the author. The paper is mathematical throughout.

H. H. Ho.

821. *Two-dimensional Motion of an Infinite Liquid.* **W. G. Bickley.** (Phil. Mag. 35. pp. 500–502, June, 1918.)—In a recent paper [Abs. 384 (1918)] Leathem has shown how to determine the motion in two dimensions of an infinite liquid occupying the space outside a solid body bounded by a closed curve or polygon, due to prescribed motion of the boundary. The method used depends on the use of periodic conformal transformations whereby the doubly connected space outside the boundary is transformed into a semi-infinite rectangle. The solution for the translatory motion is neat and immediate, but this can hardly be said of the solution in the case of rotation, although it is perfectly complete and general. When Leathem's paper appeared the present author was engaged in an attempt, since completed, to solve a particular case of the above problem, and was led to a general method of attack which seems to give results more immediately and with a less complicated procedure. An outline of the method is now presented. Conformal representation plays a large part, but instead of the periodic transformation advocated by Leathem it was found more convenient to use one whereby the doubly-connected region of the z-plane becomes the upper half of the ζ-plane, the boundary in the z-plane becoming the real axis in the ζ-plane. If the periodic transformation is known, this may be effected by taking as the auxiliary variable $\tan \pi\zeta/\lambda$ in Leathem's notation. H. H. Ho.

822. *Mass of a Material System according to the Gravitation Theory of Einstein.* **G. Nordström.** (K. Akad. Amsterdam, Proc. 20. 7. pp. 1076–1091, 1918.)—In this paper some formulæ are deduced for the mass of a material system according to Einstein's gravitation theory. The principal purpose of these formulæ is to express the mass firstly by a volume integral over the material system, and secondly by a surface integral over a surface surrounding the system. The calculations are principally based upon Einstein's paper: *Hamiltonsches Prinzip und allgemeine Relativitätstheorie,* while his article *Die Grundlage der allgemeinen Relativitätstheorie* is also utilised [see Abs. 853 (1916)]. Section 1 indicates the general formulæ used in the paper. Section 2 considers the energy of a stationary system. The author here points out that the best way of defining the mass of the system is based on the properties of the created gravitation field, at points at a great distance. Finally Section 3 contains the application to a field with spherical symmetry. H. H. Ho.

823. *Is a Moving Mass retarded by the Reaction of its own Radiation?* **L. Page.** (Phys. Rev. 11. pp. 376–400, May, 1918.)—A highly analytical paper from which the following results emerge:—

(1) J. Larmor's deduction from the electrodynamical equations of a radiation reaction on a moving mass is here shown to rest upon a tacit assumption which utterly invalidates his conclusion.

(2) It is here shown rigorously that classical electrodynamics leads to no retardation on a moving and radiating mass, but is completely in accord with the principle of relativity.

(3) The equation of motion of the Lorentz deformable electron is here computed from the electrodynamic equations as far as and including terms of the fifth order, and found to be in exact agreement with the principle of relativity. The result here obtained is claimed to be more general than any previously published, in that it is not limited to any particular type of motion, such as quasi-stationary motion in a straight line. [See Abs. 1797 (1914) and 471 (1918).] E. H. B.

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824. *Energy Components of the Gravitational Field.* **H. Bauer.** (Phys., Zeits. 19. pp. 163–165, April 15, 1918.)—In his investigation of the terms t_σ^α, designated by Einstein as the energy components of the gravitational field, Schrödinger [Abs. 331 (1918)] has proved that these magnitudes, which do not possess Tensor covariance, may disappear by a suitable choice of coordinate system as also by the existence of a gravitational field. This fact somewhat shakes that confidence in the physical significance of these terms which Einstein attributed to them. The present paper contributes further to this distrust by proving conversely that the magnitudes t_σ^α referred to a suitable system of coordinates do not vanish in the absence of a gravitational field. The author claims to have established that the energy components are not bound up with the presence of a gravitational field, but only depend on the choice of coordinates. The physical significance of these terms, therefore, appears to be doubtful. H. H. Ho.

825. *Influence exerted by Rotation of the Central Body on the Motion of the Planets and Moon according to the Einstein Gravitational Theory.* **J. Lense** and **H. Thirring.** (Phys. Zeits. 19. pp. 156–163, April 15, 1918.)—Reference is made to a previous paper [Abs. 449 (1918)] in which Thirring has approximately calculated the field in the interior of a rotating hollow sphere according to the Einstein gravitational theory. This example appeared of importance for solving the problem as to whether the rotation of distant masses produces a gravitational field according to the Einstein theory, which is equivalent to a central field. The authors submit that by the observation of disturbances in the solar system, where planets themselves rotate and move in the field of a rotating sun, a new astronomical confirmation will be afforded for Einstein's theory. The present paper contains data with deduced conclusions for the orbit elements of planetary disturbances. Section 1 deals with the calculation of the $g_{\mu\nu}$ for the field of a complete and rotating sphere. In Section 2 the equations of motion are evolved for a mass point in the field of the rotating sphere. In Section 3 the disturbances produced by the rotation of the central body are calculated. Section 4 contains 4 tables of numerical results. The disturbance terms for the planetary and lunar orbits, which on the Einstein theory are due to the rotation of the central body, are found to be smaller than those which lead to the perihelion motion of Mercury, and while too small for notice in planetary orbits, they must, however, be taken into account for the satellites of Jupiter and Saturn. The secular disturbances for the satellites of the outer planets have been calculated, but the data are too inexact for a rigid proof of the theory.
H. H. Ho.

826. *Suggestion for a European Meteorographical Office.* **R. de Saussure.** (Archives des Sciences, 45. pp. 178–190, March, 1918.)—It is suggested that it would be economical and advantageous for a central European bureau to receive weather reports daily by telegraph from a selected number of European stations, and prepare the general daily weather map, which could be issued both by code and telegraph and subsequently by printed copies to the meteorological offices of the different countries, which latter would be free to develop in detail the daily weather representation of their own countries. Various suggestions are put forward for the method of representation of wind, which are different from current practice.

An estimate of the cost of the project is put forward, and it is suggested that the proposed office should be in Switzerland. R. C.

827. *Propagation of Heat in the Lower Layers of the Atmosphere.* **H. Perrotin.** (Comptes Rendus, 166. pp. 742-744, May 6, 1918.)—This is a computation of the quantity (called by G. I. Taylor the "eddy conductivity") which, applied as coefficient of conductivity for the conduction of heat upwards from the ground to the upper layers, will produce at those layers the observed values of temperature. An example is worked out for the pair of stations in Paris: Parc St. Maur (at ground-level) and the summit of the Eiffel Tower. The eddy conductivity in summer is about 10^6 times the ordinary coefficient of conductivity of still air as determined in the laboratory. R. C.

828. *Earth Pressures.* **P. M. Crosthwaite.** (Inst. Civ. Eng., Proc. 203. pp. 124–166; Disc., 167–210, 1916–1917.)—Earlier experiments are fully summarised and discussed. Their results vary widely and in general seem opposed to Rankine's theory of earth pressures. Instead of measuring directly the ratio of vertical to horizontal pressure as the earlier experimenters did, the author, working with Rankine's theory of foundations, measures the penetration of a weighted plunger into different materials. The method is shown to give consistent results. If Rankine's theory is true the value for the angle of repose calculated from the penetration should agree with the natural angle measured directly, and the penetration should vary simply as the stress imposed. He shows that for granular material in the loosest state of aggregation the agreement is close, but that the angle of internal friction varies with the state of aggregation. If the angle proper to the compactness is taken instead of the angle of repose Rankine's theory is true for sand and granular material. Behind walls the material is always compacted and the wedge theory, introducing the plane of rupture, is invented to account for the discrepancy between the accepted angle of repose (*i.e.* that obtained from material in the loose condition) and the actual angle of internal friction, as given by the rupture of the compact earth mass. Clay, however, does not obey Rankine's laws, but seems to follow a parabolic law—the penetration being proportional to the square of the stress. In the *discussion,* **A. W. Brightmore** suggested an equation which includes both cases. Experiments given also show that the accepted method of using Rankine's theory of foundation is sound—that is, to calculate the safe depth and to go somewhat deeper assuming that there will then be no settlement if the estimated load is not exceeded. It is shown that the sand above the foundation carries the load and not that below. In an addendum experiments by **S. M. Dixon** are given proving that arch action is set up in sand so that a tunnel or hole made below the surface is not closed up even under very considerable surface loading. The paper is well illustrated with curves and tables. W. A. R.

829. *Theory of Terrestrial Deformation by Tidal Forces.* **W. Schweydar.** (K. Preuss. Geodät. Inst., Ver. No. 66. p. 51, Potsdam, 1916. Zeits. Instrumentenk. 38. pp. 65–68, April, 1918. Abstract.)—Earlier authorities on the composition of the earth's interior started from the assumption that the density as also the rigidity of the terrestrial substance, was the same for strata at all depths. Later, from results obtained at Göttingen for the propagation velocity of seismic waves in the interior of the earth, the hypothesis was put forward that for an addition of wave velocity with depth there corresponds also a change in the physical behaviour of the earth strata, chiefly with respect to density and elasticity. The changes are not uniformly propagated towards the earth's interior, but run very erratically. The data

are, however, insufficient for mathematical treatment. In consequence the theoretical examination of the influence of tidal forces upon the earth's shape is based upon the hypothesis of an uninterrupted increase of density and uniform change in rigidity towards the earth's interior. From the assumption that the earth is a sphere of incompressible material, whose density and rigidity change continuously between surface and centre and is subject to gravitational force, the author establishes the general equations in three dimensions for elastic deformations by external forces. From these he derives the radial differential equation and thence expresses the ratio of the small pressure-increase due to deformation to the original pressure in the undeformed sphere as a function of the deformation. The gravitational potential of the deformed sphere is then calculated. Finally the conditions prevailing at the surface are obtained, and the arbitrary constants of the corresponding equations deduced. Tables of data are given. H. H. Ho.

830. *The Rôle of Forces Dominating Attraction in the Architecture of the Earth and of the Universe : A Mechanical Model of the Formation of the Solar System.* **E. Belot.** (Comptes Rendus, 166. pp. 773–776, May 13, 1918.)—Although gravitation appears actually to be the preponderating force in the Universe, yet it is not more universal than all the forces revealed by Physics. If gravitation, however, had been the only force concerned with the architecture of the universe, all the masses of a system would be blended by it into a single one. It is necessary, therefore, that dispersive forces dominating attraction may operate at the origin in order to prevent such amorphous agglomeration : these are molecular attraction, pressure of gases and vapours, radiation-pressure, electrical and electromagnetic forces, etc. Impacts, whether of bulk or molecular, between masses, are capable of generating heat, electricity, and rotations, *i.e.* the majority of dispersive forces real or virtual. The growth of crystalline structure similar to that of a tree and the erection of volcanic cones or lunar craters, are due to the action of forces operating against gravity. The architecture of the earth must be traced to the primitive austral deluge. [See Abs. 828 (1914)]. This notion of architecture may be extended to the structure of masses in motion in which opposing forces produce an average stable equilibrium, *e.g.* the solar system. Since, according to Poincaré, its stability cannot be demonstrated by celestial mechanics owing to the use of semi-convergent series, there results in practice the existence of the exponential law for the distances of planets and satellites. If the effect of the tides according to Darwin, of the medium resistance according to See, or of accumulated perturbations in the same sense had prevailed in our system, their very different effects on large and small planets and upon near and remote stars, would have destroyed every appearance of the law of distances and of planetary rotation. In consequence, the author now puts forward a general proposition, namely : the architecture of the mobile masses in the universe or immobile upon the earth is not produced by attraction, but by the forces which dominate it; the attraction only ensures stability. He then describes a mechanical model which realises the architectural characteristics of the solar system with a rule of relative stability. The results obtained are compared with planetary data, and support is thereby afforded to the author's contention that it is erroneous to regard attraction as having produced the primitive dispersive impulse. H. H. Ho.

LIGHT.

831. *Naming of Optical Glasses.* **W. Zschokke.** (Zeits. Instrumentenk. 38. pp. 49–54, April, 1918.)—Describes the developments which have taken place in the production of glass for optical purposes. The paper concludes with a table giving the dispersion at various parts of the spectrum for the different glasses produced at the Sendlinger works.

A glass is described by two 3-figure numbers separated by an oblique stroke. The first number consists of the first three decimal figures in the value of the refractive index for the D line (n_D), the second figure is ten times the value of the function $\nu = (n_D - 1)/(n_F - n_D)$ for the glass in question. Thus a glass whose value of n_D is 1·5072 and for which $\nu =$ 62·8 is described as Crown glass No. 507/628. J. W. T. W.

832. *Types of Achromatic Fringes.* **C. Barus.** (Nat. Acad. Sci., Proc. 4. pp. 132–133, May 15, 1918.)—A note on the formation of the sharp fringes needed for displacement interferometry. Their definition is independent of the particular part of any of the glass plates employed, and such slight curvatures or wedge shapes as the plates may possess do not affect their formation. J. W. T. W.

833. *Interference of the Pencils which Constitute the Remote Divergences from a Slit.* **C. Barus.** (Nat. Acad. Sci., Proc. 4. pp. 134–136, May 15, 1918.)—Describes the lay-out of the apparatus used for obtaining interference between the edge rays from a slit. The fringes are difficult to find, and, when lost, are not easy to rediscover. The behaviour of the images is otherwise as described in the case of achromatics obtained by the use of a cleavage prism [see Abs. 1114 (1917)]. J. W. T. W.

834. *Optical Properties and Theory of Colour of Pigments and Paints.* **H. E. Mervin.** (Am. Soc. for Testing Materials, Proc. 17. pp. 1–34, 1917.)—A study of the optical properties of a large number of commercial pigments, with references to the vehicles and incidental remarks on the surfaces; the research was conducted in the Geophysical Laboratory of the Carnegie Institution. The hue, purity, and brightness of light diffused by a pigment or paint depend upon the refractive index, absorption, size, shape, and texture of the grains, and, further, upon the index, colour, and continuity of the vehicle and the distribution of the grains in the vehicle. A black pigment should (1) have the same refractive index for grain and medium, and (2) grains of 1 μ or less, (3) be just barely opaque for all colours; only bone black fulfils condition (1), whilst most satisfy (3) and also (2). White pigments should have even grains of 0·5 μ to 1 μ; finer grains diffuse blue light by preference, *e.g.* when mixed in oil with black or dark red pigments, so that blue greys and purples result; most white pigments contain enough fine grains to appear bluish; larger grains have too little reflecting surface per volume; control of grain size is therefore desirable. The burning of blende (instead of metallic zinc) gives less even grain, and in the presence of lead large grains; extremely fine division may favour the quantity of colour in mixtures with strongly diffusing pigments; under other conditions size and shape of grain and index are of great importance. Thus, in Harrison red, HgI_2, the diffusing power changes noticeably with the

shape of the uneven, birefringent grains. The paper discusses the suitability of the pigments for producing shades and tints and the effects of mixing them with black and white and of wetting them, and describes methods for determining the optical constants. H. B.

835. *Scattering of Light by Dust-free Air.* **R. J. Strutt.** (Roy. Soc., Proc. 94. pp. 453–459, June, 1918.)—It is now well established that the luminosity and blue colour of the sky on very clear days and at considerable altitudes above the sea-level can almost completely be accounted for by the scattering of light by the molecules of the air, without postulating suspended particles of foreign matter, such as were thought necessary by the earlier writers. The present paper gives an account of a laboratory experiment exhibiting the scattering of light by dust-free air. The source of light (either a carbon arc or a quartz mercury lamp) was arranged to give a convergent beam, a quartz lens being used. This beam passed through a quartz water-cell to absorb heat rays, and then into the experimental vessel. The latter was in the form of a cross ABCD, made of brass tubing 1¼ in. in diam., and its interior was dead-black. The light entered by the quartz window in A and passed through a rectangular diaphragm to the end of C, where it was stopped by the end of the tube. The beam was observed through a glass window at the end of D. The opposite tube B constituted a black cave, giving the necessary black background against which the feeble transverse luminosity of the beam could be observed. In spite of all precautions, enough light was diffused by the walls of the tube to enclose this black background in a luminous ring, which, however, was not bright enough to cause inconvenience. With ordinary air in the apparatus a very bright track due to scattering by the dust particles was observed, but with well-filtered air only a blue track along the beam was visible, much fainter than the original dusty track, but visible without difficulty when the eyes had been rested in the dark. The track of the beam in dust-free air was much bluer than the original dusty track, which was about the same colour as the arc, and also was much bluer than the ring of light scattered by the walls of the vessel. When the vessel was exhausted the blue track disappeared, nothing remaining except the ring of light diffused by the vessel. Various tests and precautions seem to prove beyond doubt that the observed scattering was not due to dust, but that it is a property of pure air. Spectroscopic investigation showed that what had been observed could not be attributed to fluorescence, a 2-hour exposure bringing out faintly the great cyanogen band at λ3880, which is photographically the most conspicuous feature of the carbon arc spectrum. Polarisation tests showed further that the scattered light is almost completely polarised. Visual examination with a nicol showed that the beam was invisible when the prism was held with its short diagonal horizontal. Thus the vibrations are transverse to the direction of propagation, as in all cases of scattering by particles small compared with the wave-length. Similar results can be obtained with other gases. Hydrogen gives much less scattering than air, oxygen about the same, CO_2 decidedly more, but the scattered light in all cases is the blue of the sky, illustrating very directly the theory that attributes the blue of the sky to scattering by the molecules of air. All the results are in qualitative agreement with theory. Quantitative experiments are in progress and will be described later. A. W.

836. *Variation in Blackening of Photographic Plate with Time of Exposure, the Total Energy remaining Constant.* **P. S. Helmick.** (Phys. Rev. 11. pp. 372–

375, May, 1918. Paper read before the Am. Phys. Soc., Dec., 1916.)—For many years following the discovery of photochemical action, it was believed that if the product of the intensity of light producing the exposure and the time of exposure were constant, the resulting photochemical effect would be constant. Subsequently variations from this so-called "reciprocity law" were noted [see Abs. 1287 (1914)], but attention was directed to the determination of relations between intensity and time which would give constant blackening, rather than to finding the variation in the blackening with time, with total energy remaining constant. Abney and Kron seem to have made the only progress in this last-named problem. Both claim that when blackening is plotted against exposure, with total energy remaining constant, the resulting curve will show a maximum; but neither investigator directly obtains his curve. It has been the purpose of the author to investigate Abney and Kron's conclusion, and actually obtain the curve showing the maximum, if it existed. By exposing the plate to different rates of flow of constant light-energies, it was believed that some additional knowledge of the physical mechanism in a light-sensitive plate might be gained. The apparatus and method employed are described. The curves given show that the blackening of a plate is dependent upon the rate of flow of energy, with total energy constant, and that for each brand of plate and quantity of total energy there is a max. blackening given by a certain rate of flow of energy. The relation between the time of exposure to produce max. blackening and the speed of the plate seems significant, for with the same value of total energy upon each plate, the positions of the maxima vary as the speeds of the plates. By using this rule it is possible to shift the maxima of the curves at will. A. E. G.

837. *Brightness of the Black Body and the Mechanical Equivalent of Light.* **G. Holst** and **J. S. de Visser.** (K. Akad. Amsterdam, Proc. 20. 7. pp. 1036–1042, 1918.)—Describes a new determination of the brightness of the black body at the melting-point of gold. The experiment was so arranged that the intensities to be compared were well above the limit of the Purkinje-effect. The value obtained for the brightness at 1336° was 0·119 hefner candle per cm.^{2}, which agrees well with other recent determinations [see Abs. 1252 (1916) and 1117 (1917)]. The mechanical equivalent of light was thus calculated to be 51·7 hefner candles per watt. J. W. T. W.

838. *Intensity Distribution in Series Spectra.* **J. Holtsmark.** (Ann. d. Physik, 55. 4. pp. 245–298, May 24, 1918.)—Earlier investigations on the intensity distribution in the series lines of hydrogen were subject for the greater part to many sources of error. It appears that the excitation by canal or kathode rays is better in many respects for the purpose in question than the use of Geissler tubes with either alternating or direct current. Vegard has investigated the Balmer series, using canal rays [Abs. 497 (1917)], and Holtsmark [Abs. 1586 (1914)] has shown that the intensity distribution in the Balmer series is independent of the current strength and also of the potential in the case of kathode-ray excitation. It was found, however, that with increased gas pressure the lines towards the red end of the spectrum were relatively strengthened. This pressure effect has now been further investigated, and it appears from the results obtained that the connection between the intensity-ratio χ of the two lines H_β and H_γ and the pressure p is within the limits of the observational errors, represented by the equation $\chi p^{-0\cdot126} = \text{constant}$. A similar relation holds good for H_α and H_β. The latter part of the paper consists of a discussion of the results obtained for the

pressure effect in relation to Bohr's theory of atomic structure. [See Abs. 281 (1914).] A. W.

839. *Stark-effect for Hydrogen Lines.* II. **T. Takamine** and **U. Yoshida.** (Kyōto Coll. Sci., Mem. 2. pp. 321–323, Oct., 1917.)—Continuing their research [Abs. 955 (1917)] the authors have obtained new data, and several doubtful points of the earlier work were settled. Lo Surdo's method [Abs. 666 (1914)] was again used. The various modes presented by the affected secondary lines are shown diagrammatically. Besides these a number of lines show a considerable broadening toward the red side in strong fields. The wave-lengths of these seven broadened lines range from λ4461·1 to λ4764·0, and in all cases the *s*-component shows the effect, while with λ4511·9 and λ4764·0 the *p*-component is also broadened. Including the broadened lines, 15 affected lines have been discovered besides the 17 given previously [Abs. 955 (1917)]. It was noticed that the outer components of the Balmer lines often extended beyond the unaffected neighbouring lines belonging to the secondary spectrum. According to Stark, the carriers for the Balmer lines are the positive atomions, while those of the secondary spectrum lines are the neutral hydrogen atoms. From the effects now observed it seems very probable that the Balmer lines and those of the secondary spectrum are due to different carriers, as there appears to be no mutual influence between them. A. W.

840. *Stark-effect for Helium Lines.* **T. Takamine** and **U. Yoshida.** (Kyōto Coll. Sci., Mem. 2. pp. 325–334, Oct., 1917.)—With the same experimental arrangements as used in their investigation of the Stark-effect for hydrogen lines [Abs. 955 (1917) and preceding Abs.] the research has been extended to helium. Relying on Stark's data, the intensity of the electric field was calculated from the amount of separation of the outer components of H_γ, which appeared together with the helium lines. The lines λλ5048, 5016, 4922, 4472, 4438, and 4121 were examined in fields varying in strength from 3000 to 70,000 volts/cm. and the manner of decomposition was compared with the measurements of Stark, Brunetti, and Koch. In each of the *p*- and *s*-components of the three lines λλ4922, 4472, and 4388 an isolated component appeared on the violet side for a certain strength of the electric field, and in the case of the λ4472 line this component was further decomposed into three as the field strength increased. The separation of the *p*-component of the line λ4686 has also been observed, and diagrams are given for all the lines dealt with. Excepting the line λ4686, the mode of decomposition of all the helium lines examined has been found to be unsymmetrical with respect to the initial line. A. W.

841. *Stark-effect for Hydrogen Lines.* **S. Nitta.** (Kyōto Coll. Sci., Mem. 2. pp. 349–355, Oct., 1917.)—The author has studied the mode of decomposition of the lines H_β, H_δ, and H_ϵ, as well as a number of lines belonging to the secondary spectrum of hydrogen, and the results are given in the present paper. The same experimental arrangement was adopted as was employed by Takamine and Yoshida [Abs. 955 (1917) and preceding Abs.]. By lowering the pressure in the discharge tube until the end of the Crookes dark space became very indistinct, a field intensity far greater than those obtained by the former investigators was attained, its max. value being about $14{\cdot}6 \times 10^4$ volts/cm. For H_β six *s*-components have been observed and identified with those obtained by Stark. The proportionality between the amount of separation and the field intensity was found to hold good for these components. Two *p*-components and four *s*-components were obtained with both H_δ and H_ϵ, and, excepting the four *s*-components of H_ϵ, these have been identified with the components obtained by Stark. The secondary spectrum lines measured, of which diagrams are given, were in the regions from λ4840 to λ3900, and in the neighbourhood of H_β. A. W.

842. *Energy in the Continuous X-ray Spectra of Certain Elements.* **C. T. Ulrey.** (Phys. Rev. 11. pp. 401–410, May, 1918.)—The continuous X-ray spectra of Pt, W, Pd, Mo, Ni, and Cr have been investigated by the X-ray spectrometer method as developed by W. H. and W. L. Bragg [Abs. 1880 (1913)]. By comparison of the areas and max. ordinates of the radiation curves of the above elements it appears that the energy emitted in the form of X-radiation in this part of the spectrum is not directly proportional to the atomic weight or the atomic number, but is a periodic function of either, the periodicity coinciding with that of the chemical periodic system.

The continuous spectrum of tungsten has been examined over a range of voltage from 20 to 50 kilovolts. Within this range the following relation between the wave-length of max. energy, $\lambda_{\text{max.}}$, and the voltage is found to hold: $\lambda_{\text{max.}} V^{1/2} = \text{const.}$ The areas under the tungsten radiation curves are proportional to the square of the voltage between 25 and 40 kilovolts.

A. B. W.

843. *Scattered X-radiation due to Heat Motion of the Molecules in Crystalline Reflection of X-rays.* **H. Faxén.** (Ann. d. Physik, 54. 8. pp. 615–620, April 26, 1918.)—In a paper on "Interference of X-rays and Heat Motion," P. Debye calculated the effect of heat motion of the crystal molecules on the reflecting properties of the crystal [see Abs. 1078 (1914)]. The author now calculates, as a direct consequence of Debye's work, the extent of the scattering produced by heat motion. In general, his results are in agreement with Debye's; but it is also shown that the scattered radiation reaches its max. value in the neighbourhood of the interference maxima—in which case Debye's formula for scattering no longer holds. A. B. W.

844. *The Geometry of Image Formation in X-ray Analysis.* **H. S. Uhler.** (Phys. Rev. 11. pp. 1–20, Jan., 1918.)—The paper deals with the general theory upon which the construction of X-ray spectrometers and spectrographs should be based. General equations are derived for the incident and reflected rays, and it is shown that in general not more than two rays can be constructed when one point on the incident segment, one on the reflected segment and the glancing angle are given. The following theorem of the focal circle is proved in a perfectly general manner: all rays lying in a plane perpendicular to the axis of rotation of a plane selective mirror—the axis coinciding with the mirror (pure rotation)—and radiating from a single point will, after reflection, pass through two focal points each of which is at the same distance from the axis as the radiant point, the angles of deviation of the axial or principal rays of the pencils being numerically equal to twice the constant glancing angle. This fundamental theorem is not new as demonstrations of it involving only elementary non-analytic geometry have already been given by Bragg, Wagner, and others. The theorem involves the following assumptions: (*a*) The rays of a pencil must all lie in one plane perpendicular to the axis of rotation of the crystal, (*b*) the rays must not penetrate the crystal to a

finite depth, (*c*) the reflecting plane must contain the axis of rotation, and (*d*) the slit must act as a mathematical line source.

It is shown analytically that a circular envelope arises when the reflecting plane is parallel to the axis of rotation but does not contain the axis. Special properties of this locus are demonstrated. Rays having finite angular altitude produce asymmetric broadening of the spectral images even when the azimuth is zero. When the angular altitude is constant and the azimuth is finite and variable, the bundles of rays have astigmatic properties. This broadening is always in such a direction as to lead to too large a value for the glancing angle. The effect of tilting the reflecting planes of atoms with respect to the axis of rotation on the slope of the spectral lines is also considered.

A new method is described for the accurate determination of glancing angles, and two ways of applying it are suggested. One of these ways has been tested experimentally and found very satisfactory. E. A. O.

845. *Resolving Powers of X-ray Spectrometers, and the Tungsten X-ray Spectrum.* **E. Dershem.** (Nat. Acad. Sci., Proc. 4. pp. 62–65, March, 1918.)—From simple considerations of crystal reflection the author shows that the resolving power of a given crystal may be expressed as follows :—

$$\lambda/\Delta\lambda < nr\lambda/[d \cos\theta\,(s + 2t\cos\theta)],$$

where λ is wave-length of X-radiation reflected at the angle θ, d the "grating space" of the crystal, s the width of the X-ray beam, t the thickness of the crystal, and n the order of the spectrum.

From this expression it appears that the resolving power may be increased by increasing the order of the spectrum and the distance between the crystal and the photographic plate, and also by decreasing the width of the source and the thickness of the crystal. To increase the resolving power by any of these means results in a loss of intensity which must be compensated for by an increased time of exposure.

Using a Coolidge tube, with tungsten target, and reflecting from a rock-salt crystal the author has made a series of careful measurements of the wave-lengths in the X-ray spectrum of tungsten. The results, which are tabulated, are claimed to be accurate within 0·1 % in the case of L-radiations and 0·8 % in the case of K-radiations. In the case of the L-lines the resolving power, as defined above, was less than 170, but nevertheless 19 separate and distinct lines were obtained. A. B. W.

846. *Colour Determination of Faint Luminescence.* **H. B. Weiser.** (J. Phys. Chem. 22. pp. 439–449, June, 1918.)—Considering all the possible sources of error, it appears that the determination of the colour of faint luminescence with the unaided eye is unsatisfactory. A method has been devised whereby the colour may be determined with a considerable degree of accuracy. The method consists essentially of photographing the luminescence on a panchromatic plate, interposing a series of different-coloured screens between the source of light and the plate. By comparing the photograph so obtained with a photograph of white light, using the same colour-screens, the colour of the luminescence is readily determined. The method is applicable in all cases where the glow is uniform and sufficiently strong to fog the most sensitive photographic plate brought very close to it. The applicability and usefulness of the method is illustrated by means of a number of solution reactions varying in intensity from the relatively bright oxidation of alkaline pyrogallol to the faint crystallo-luminescence of sodium chloride. It is shown that in the oxidation of pyrogallol the luminescence is made up of a band extending from the red through the yellow, with the maximum in the orange-red. The luminescence observed when a solution of phosphorus in glacial acetic acid is treated with hydrogen peroxide is found to be the same in quality as white light from the yellowish-green through the violet. In the oxidation of amarine with chlorine or bromine, the colour of the luminescence is the same in both cases, and has its maximum in the neighbourhood of the thallium green line. When a saturated salt solution is mixed with alcohol or hydrochloric acid, precipitation takes place with emission of light. Photographs show the colour of this light to be bluish-violet. A. W.

RADIO-ACTIVITY.

847. *The Parent of Actinium.* **F. Soddy** and **J. A. Cranston.** (Roy. Soc., Proc. 94. pp. 384–404, June 1, 1918.)—In a full historical introduction, the data obtained in 1909 relative to the rays and products of uranium X are discussed in so far as they throw light on the various possible modes of origin of actinium. The minute growth of actinium previously put on record [see Abs. 1075 (1918)] as having been observed in the old uranium preparations has been confirmed by their later history and is now established beyond doubt.

Uranium X_2 can be separated from UrX_1 by sublimation in a current of air charged with vapours of carbon tetrachloride at a temperature below visible red-heat. 470 gm. of a very pure Indian pitchblende were similarly treated, in the expectation of removing eka-tantalum, isotopic with UrX_2 and giving actinium in an α-ray change of long period. The preparations so obtained were initially free from Ac, but one of them has produced it continuously with the lapse of time. A direct comparison of the amount of Ac in this preparation after the lapse of 2·5 years with that in the original pitchblende showed that it was equal to that in about 0·25 gm. On the assumption that eka-tantalum and actinium are both long-lived, that no intermediate members intervene between them, and that the preparation contained the whole of the parent Ac in the original mineral, the period of average life of Ac is calculated to be 5000 years. Nothing can yet be said definitely as to the period of the parent.

A second preparation separated from Joachimsthal pitchblende, the treatment of which commenced in 1908 and ended in 1914 with the carbon tetrachloride sublimation, has given a similar growth of actinium. The work was undertaken to test and confirm the view that the parent of Ac occupies the eka-tantalum place in the Periodic Table, and gives actinium in an α-ray change of long period, being itself formed as the product of UrY, discovered by Antonoff, who suggested that it was the first member of the Ac series. But this mode of origin of actinium, though at present the most probable, has not yet been conclusively established to the exclusion of all the other possible modes of origin, discussed in the historical introduction. A. B. W.

HEAT.

848. *A Simple Boiling-point Apparatus for Testing Mercury Thermometers at Temperatures over* 100° C. **G. Dimmer.** (Zeits. Instrumentenk. 38. pp. 38–40, March, 1918.)—For the testing of mercury thermometers at higher temperatures the author recommends the use of vapour baths. The thermometer is hung in a long-necked flask which contains a suitable substance of known boiling-point (aniline, 184·1°; naphthalene, 218°; benzophenone, 306°; sulphur, 444·6°). This flask is surrounded by a wider tube, with trumpet-shaped opening at the lower end. By this means the hot gases ascending from the heating burner are caused to surround the inner boiling tube and so to form a hot-air mantle which greatly increases the constancy of the temperature within the boiling tube. The bulb of the thermometer is surrounded by an inverted Al cone which prevents the condensed vapour running down the bulb. Circulation of the vapour of the boiling liquid round the bulb is, however, secured by perforating the sides of the protecting cone. A. F.

849. *Thermal Conductivity in Metals.* **E. H. Hall.** (Phys. Rev. 11. pp. 329–330, April, 1918. Abstract of paper read before the Am. Phys. Soc., Dec., 1917.)—It is generally admitted that there are free electrons in the interatomic spaces of a metal and that their number increases with temperature. Hence there must be, in a detached metal bar hot at one end and cold at the other, a mechanical pressure tending to drive the free electrons down the temperature gradient. If this tendency prevails, even to a slight extent, it makes the hot end of the bar electrically positive and the cold end negative. It is then argued that the electrons will function somewhat like a vapour, and will absorb heat at the hot end and give it out at the cold. A few numerical data are given in support of this idea. E. H. B.

850. *Atomic Heats of Tungsten and Carbon at Incandescence.* **A. G. Worthing.** (Frank. Inst., J. 185. pp. 707–708, May, 1918.)—According to modern theories the atomic heat of a solid at constant volume should have the upper limiting value of 5·95 gm. cals. per gm. atom per deg. This value seems to be exceeded, however, by several substances already at 700° or 800° C. Determinations were made at the Nela Research Laboratories with filaments in evacuated bulbs. In a filament of mass m uniformly heated by a current of intensity I at V volts the rate of energy supply is equal to the sum of the rates of radiation and of storing up energy; hence $IV = f(T) + C_p m \,.\, dT/dt$, where C_p is the specific heat, T the temperature, t the time, both for heating and cooling. Introducing the resistance R and assuming that during temperature-changes both T and the radiation rate are single-valued functions of R, the formula becomes: $IV = F(R) + C_p m \,.\, dT \,.\, dR/dR \,.\, dt$. With the aid of pendulum switches and a potentiometer I and V are determined as functions of t for definite temperature-changes, and R is thus expressed as a function of t. In the case of tungsten the heating and cooling did not give quite the same results, which may indicate that the assumption of single-valued functions is not justified; but this is not considered proved. Taking the results as a whole, however, the atomic heat of tungsten would be represented by a straight-line relation, being 6·25 at 1200° and 7·85 at 2400° K.; these values are considerably in excess of the 5·95 limit. In the case of carbon the experiments were not conducted with the same great care; the results, 5·85 at 1200° and 6·05 at 2,000° K. for the atomic heat at constant pressure, would be compatible with an upper limit of 5·95 at constant volume, and these figures agree with the figures of Weber and of Magnus for diamond and graphite at ordinary and at higher temperatures. [See also Abs. 74 and 276 (1918).] H. B.

851. *Remarks on the Statistical Foundations of the Quanta Theory.* **L. Flamm.** (Phys. Zeits. 19. pp. 116–128, March 19, and pp. 166–168, April 15, 1918.)—Consequent on an idea of Einstein, the author has been able to evolve the quanta theory in a particularly simple manner starting from the following fundamental assumption: The homogeneous elementary parts (molecules, atoms) of a body take in discontinuous manner only a limited series of defined states with corresponding energy values. The quanta loss and gain of energy of such a body follows as an immediate consequence. From statistical considerations, therefore, the thermodynamic behaviour of such a body may be derived without further assumption. The correct final formulæ are then arrived at when the possible states are all regarded as equally probable. The author in the second article shows that the general formulæ for the thermodynamically important functions may be calculated in an equally simple manner without the above assumption, and in the present paper he derives the fundamental formulæ for the calculation of energy, entropy, and specific heat of a body at constant volume, using the smallest number of special assumptions in the most general way. H. H. Ho.

852. *Energy Partition and Quantum Theory.* **R. C. Tolman.** (Phys. Rev. 11. pp. 261–275, April, 1918.)—A mathematical discussion of the general theory. [See Abs. 1119 (1918).] E. H. B.

853. *Tensions of the Saturated Vapours of Triatomic Liquids.* **E. Aries.** (Comptes Rendus, 166. pp. 668–672, April 29, 1918.)—In the application to triatomic bodies of the formulæ $\Pi = \tau^{2+n}Z/x$, $x = \Gamma\tau^{1+n}$, the experimental data in existence do not furnish satisfactory material for the proper solution of the problem. The best of these, namely the data for carbonic acid, are first considered. By a similar procedure to that undertaken for monatomic and diatomic bodies, a value of $\frac{4}{5}$ has been taken for the exponent n, which enables the deduction of function Γ for each observation temperature. Starting from unity at the critical state, this value diminishes very slowly at the outset but more rapidly as far as the lowest temperatures observed by Amagat and Regnault. Cailletet's experiments, however, afforded different results; but as the behaviour of the tension of the saturated vapour of carbonic acid at low temperatures is in opposition as also the data for other triatomic bodies, the author excludes Cailletet's experiments for the determination of the function Γ. Passing from the critical temperature this function, at first slightly below unity, resumes this value in the case of triatomic bodies at a reduced temperature of $\tau = 0{\cdot}88$. This result occurs with monatomic bodies for $\tau = 0{\cdot}84$, and for diatomic when $\tau = 0{\cdot}86$. The general form of the function Γ based on the experiments of Amagat and Regnault is thus: $\Gamma = 1 + [(1 - \tau \times 0{\cdot}88 - \tau)]/[0{\cdot}40(\tau^2 + 1)]$ and the above formulæ become $\Pi = \tau^{2+4}Z/x$, $x = \left(1 + \frac{(1-\tau)(0{\cdot}88 - \tau)}{0{\cdot}40(\tau^2 + 1)}\right)\tau^{1+4/5}$

Sulphurous acid and nitrous oxide are next discussed; their behaviour is found to be well represented by these formulæ. A complete table of data is included for the three substances in question, and the conclusion drawn that

their vapour tensions obey the law of corresponding states and may be expressed by a single formula which will not differ appreciably from the above. From the available data, carbon disulphide is also found to behave normally. On the other hand sulphuretted hydrogen, like water, gives results which are in complete discord with the formula. Now, water at ordinary temperatures is polymerised, but at higher temperatures the data, which, however, are yet very indecisive, show a tendency to fit in with the formula, so that at the proper points the above formula appears to be justified for triatomic bodies.
H. H. Ho.

854. *The Adiabatic Hypothesis and the Boltzmann Principle.* **A. Smekal.** (Phys. Zeits. 19. pp. 137–142, April 1, 1918.)—The relationship of the adiabatic hypothesis to the statistical foundation of the second law of thermodynamics has only been found hitherto by Ehrenfest [Abs. 408 (1917)] for the totality of molecules with one degree of freedom. In the present paper it is shown that the assumption of an adiabatic invariant quanta hypothesis for the totality of a given stable system with several degrees of freedom is necessary for the validity of the Boltzmann Principle. [Abs. 388 (1918) should be consulted.]
H. H. Ho.

855. *The Definiteness of Macroscopic Processes and the Kinetic Theory.* **[Mrs.] T. Ehrenfest-Afanassjewa.** (K. Akad. Amsterdam, Proc. 20. 7. pp. 1049–1058, 1918.)—Let a definite quantity of gas be taken as a system containing a very great but finite number, N, of molecules which obey certain conservative laws of motion. Then all successive states of the system are for all times perfectly determined by 6N "microscopic coordinates," *e.g.* the 3N space-coordinates and the 3N velocity-components for all molecules at a definite but arbitrarily chosen moment t_0. These quantities are not, however, directly observable; it is only possible to observe certain statistical mean values of these quantities: the "macroscopic coordinates," which at a definite moment give insufficient determining quantities thereby rendering impossible the derivation of the microscopic quantities from the combination of the macroscopic. Therefore while the microscopic state of the gas at one moment perfectly determines the progress of the successive "micro-" and also "macroscopic" states, the macroscopic state at one moment is not sufficient to determine the progress of the microscopic state, nor of the successive macroscopic states. In consequence, though the kinetic theory of gases involves fundamentally a well-defined determination of the processes in a gas, it teaches at the same time that it is practically impossible to obtain any knowledge of this determination and that the succession of macroscopic states of a gas is in effect as the successive drawings of a lottery, *i.e.* after a definite given state all possible different states may be expected and only certain considerations on probability are at disposal. The same is true when the kinetic conceptions are extended to the whole world. Yet, in the establishing of physical laws and in applying them, every physicist behaves as if he were perfectly convinced of all macroscopic processes being determined by the macroscopic coordinates alone. The question arises, Is this intuitive way of thinking, which has always proved very fruitful, in incompatible antagonism with the kinetical conception—which on the other hand has also proved to be useful—or may a closer investigation prove these two conceptions to be reconcilable? The present paper contains an attempt to indicate the way in which such a reconciliation between the two conceptions may be approached. H. H. Ho.

SOUND.

856. *Mathematical Theory of Sound Ranging.* **H. Bateman.** (Monthly Weather Rev. 46. pp. 4–11, 1918.)—The development of the art of concealing large guns so that they cannot be easily seen by hostile airmen or observers in kite balloons has brought into prominence the study of the methods of locating powerful guns by means of observations of the time of arrival of the sound of their gunfire at one or more observing stations. There are really two distinct problems to be discussed: (1) The simple case is when the flash is seen and the distance of the gun is to be determined from the observed interval of time between the instant when the flash is seen and the report is heard at a single station. (2) The more complex case is when the flash is not seen. The sound of the report must then be timed at three or four observing stations and the position of the gun estimated from the observed differences in time.

The simple theories are then developed and also a general theory of the rays of sound. The paper concludes with some numerical cases. E. H. B.

857. *Rotation of Pulley in Melde's Experiment.* **A. T. Jones.** (Phys. Rev. 11. pp. 150–152, Feb., 1918. Abstract of paper read before the Am. Phys. Soc., Rochester, Oct., 1917.)—Let the string pass horizontally from the fork to the pulley and then down to the load and let the prongs of the fork vibrate toward and from the pulley. Then if the fork vibrated slowly enough the load would move up and down and the pulley would rotate to and fro. With the frequencies used there is a net rotation of the pulley, which may be in the sense towards or from the fork according to the conditions in use as to amplitudes and loads. E. H. B.

858. *Beats.* **E. Waetzmann.** (Phys. Zeits. 18. pp. 560–567, Dec. 1, 1917.)—A reply to a recent paper on the same subject by E. Budde [Abs. 1293 (1917)]. Waetzmann develops the subject mathematically, and then illustrates special cases by graphs in which the amplitudes are at first equal and afterwards unequal. A discussion then follows as to the pitches of the tones heard and the views of Budde are criticised. **E. Budde.** (*Ibid.* 19. pp. 60–61, Feb. 15, and pp. 177–178, May 1, 1918.)—Budde replies to Waetzmann and deals with several points at issue between the two authors. E. H. B.

859. *Wolf-note in Bowed Instruments.* **C. V. Raman.** (Phil. Mag. 35. pp. 493–496, June, 1918.)—J. W. Giltay has questioned [Abs. 1160 (1917)] the correctness of some earlier remarks of the author [Abs. 1366 (1916)] in explanation of the effect of a "mute" on the tone of bowed instruments, namely, that this is to be sought chiefly in the lowering of the frequencies of resonance of the instrument produced by the loading of the bridge. It is now pointed out by the author that his view of the action of the mute rests upon the secure foundation of mathematical analysis. Upon this foundation the further test of experiment is now built up and completely vindicates the position first taken up. E. H. B.

860. *Wolf-note in Pizzicato Playing.* **C. V. Raman.** (Nature, 101. p. 264, June 6, 1918.)—This note is accompanied by a photograph, showing the simultaneous vibration curves of the G-string and bridge of a 'cello played pizzicato at the wolf-note pitch. This photograph shows the extremely rapid

dissipation of energy, and also the effect of the motion of the bridge on the vibration of the string. Indeed the phenomena may be regarded as constituting a strongly damped *coupled* vibration of string and bridge. And this in many respects differs from the cyclical vibration excited by *bowing* at the wolf-note pitch previously described by the author [see preceding Abs.].

E. H. B.

861. *Propagation of Sound and Light in an Irregular Atmosphere* **Rayleigh.** (Nature, 101. p. 284, June 13, 1918.)—Probably most of those who have listened to (single-engined) aeroplanes in flight, have noticed the highly uneven character of the sound, even at moderate distances. It would seem that the changes are to be attributed to atmospheric irregularities affecting the propagation rather than to variable emission. This may require confirmation; but in any case, a comparison of what is to be expected in the analogous propagation of light and sound has a certain interest.

One point of difference should first be noticed. The velocity of propagation of sound through air varies indeed with temperature, but is independent of pressure (or density), while that of light depends upon pressure as well as upon temperature. In the atmosphere there is a variation of pressure with elevation, but this is scarcely material for the present purpose. And the kind of irregular local variations which can easily occur in temperature are excluded in respect of pressure by the mechanical conditions, at least in the absence of strong winds, not here regarded. The question is thus reduced to refractions consequent upon temperature variations.

The velocity of sound is as the square root of the absolute temperature. Accordingly for 1 deg. C. difference of temperature the refractivity $(\mu - 1)$ is 0·00183. In the case of light the corresponding value of $(\mu - 1)$ is $0{\cdot}000294 \times 0{\cdot}00366$, the pressure being atmospheric. The effect of temperature upon sound is thus about 2000 times greater than upon light. If we suppose the system of temperature differences to be altered in this proportion, the course of *rays* of light and of sound would be the same.

When we consider mirage and the twinkling of stars and of terrestrial lights at no very great distances, we recognise how heterogeneous the atmosphere must often be for the propagation of sound, and need no longer be surprised at the variation of intensity with which uniformly-emitted sounds are received at moderate distances from their source.

The effect of the immense disproportion of wave-lengths is also considered as between light and sound.

E. H. B.

862. *Transmission of Sound through Earth and Rock.* **L. V. King** and **A. N. Shaw.** (Roy. Soc., Canada, Trans. 11. pp. 73–84, 1917.)—(1) The Fessenden submarine telegraph oscillator was found to provide an extremely powerful means of setting up vibrations in earth and rock. (2) By a submarine microphone of the carbon granule type, it was possible to detect the vibration of the oscillator at 100 ft. or more.

E. H. B.

ELECTRICITY AND MAGNETISM.

DISCHARGE AND OSCILLATIONS.

863. *Mobilities of Gaseous Ions.* **Kia-Lok Yen.** (Phys. Rev. 11. pp. 337–362, May, 1918. Paper read before the Am. Phys. Soc., Dec., 1917.)—The author summarises as follows:—(1) the previous experiment of Loeb on the ionic mobilities in air has been repeated and confirmed. (2) The law $Up =$ constant was found to hold for the negative ions from 184 to 12,870 volts/cm., or from $x/p = 0{\cdot}18$ to $20{\cdot}70$; and for positive ions from 186 to 14,160 volts/cm., or from $x/p = 0{\cdot}22$ to $22{\cdot}04$. (3) The experiment was extended to hydrogen and nitrogen, and the law $Up =$ const. was found to hold in both cases. (4) The law $Up =$ const. was verified in hydrogen for negative ions from 9 to 5668 volts/cm., or from $x/p = 0{\cdot}38$ to $12{\cdot}15$; and for positive ions from 16 to 6669 volts/cm., or from $x/p = 0{\cdot}66$ to $14{\cdot}45$. (5) In nitrogen, the negative mobility was found to remain constant from 11 to 14,880 volts/cm., or from $x/p = 0{\cdot}05$ to $29{\cdot}0$; and the positive mobility constant from 15 to 17,670 volts/cm., or from $x/p = 0{\cdot}07$ to $40{\cdot}0$. (6) Free electrons were found to exist in both hydrogen and nitrogen, even at atmospheric pressure: more in hydrogen than in nitrogen. (7) More free electrons were found with low potentials than with high potentials. (8) The ageing effect upon the gases at constant pressure was to reduce the relative amount of the free electrons. (9) No indication was found of Haines' negative ions B and C [Abs. 1729 (1915); 712 (1916)], and in general no indication was found so far which would prove to be favourable to the cluster theory. (10) The difference between positive and negative mobilities is explained by the nucleus-atom theory, and the experiment is in progress with the gases where the proposed explanation does not seem to be applicable. A. B. W.

864. *Ionisation of Gases.* **H. Greinacher.** (Phys. Zeits. 19. pp. 188–195, May 1, 1918.)—A series of experiments suitable for demonstrating the following points are described.

(1) The potential gradient in a gas through which a current is flowing. An apparatus is described by means of which it is possible to compare the potential with that in an electrolyte direct.

(2) Alteration of pressure in gases when conducting electricity, (*a*) in the case of the point discharge, (*b*) when the gas contains both kinds of ions, as in the case of ionisation by X-rays.

(3) The positive potential to which a zinc plate becomes charged as the result of photoelectric action is obtained after removal of the electro-negative layer of ions by a wind blast.

(4) Experiments on unipolar conductivity produced by salt vapours in flames. A. E. G.

865. *Adsorption in Vacuum Tubes.* **W. D. Bancroft.** (J. Phys. Chem. 22. pp. 345–347, May, 1918.)—It is uncertain whether the change in the vacuum of a Crookes' tube can be said to be due to the adsorption of the gas by the glass or not. In this paper the experiments made by Swinton [Abs. 1887 (1907) are criticised, and the following points are made.

In a Crookes' tube gas-bubbles may be driven into the glass for a distance of about 0·1 mm. This gas is set free when the glass is pulverised. It is not known whether the glass flows round behind the bubbles, cutting them off completely from the inner portion of the tube, or whether the holes made by the bubbles in passing into the glass do not close completely. If the bubbles are sealed in the glass, this is merely a case of mechanical entanglement; but if the bubbles are connected with the inner portion of the tube by fine pores it is a case of adsorption. Hydrogen and helium tubes behave alike. A. E. G.

866. *Distribution of the Electric Field in the Crookes' Dark Space in a Narrow Tube.* **T. Takamine and U. Yoshida.** (Kyōtō Coll. Sci., Mem. 2. pp. 335–340, Oct., 1917.)—In this work the photographs taken in connection with the investigation of the Stark-effect in hydrogen and helium [Abs. 955 (1917), 839, 840 (1918)] were employed, use being made of Stark's conclusions relative to the outer components of H_γ. The glow was never uniform in the dark space, but was mainly concentrated in the axial portion of the tube, except just in front of the kathode, where a glow of nearly uniform intensity occupied the whole section of the tube. The intense glow in the central portion of the tube was projected on the slit of a spectrograph, and it is accordingly to this part of the tube that the intensity measurements apply. Measurements based on the *p*- or the *s*-components of H_γ were found to agree in every case examined. If V is the potential of any point in the dark space at a distance x from the kathode, Schuster proposed the formula $V = V_0(1 - \epsilon^{-kx})$, where V_0 is the potential in the glow proper, k is a constant, and the potential of the kathode is taken as zero. If Schuster's formula is applicable to the case here considered, the graphical relation between log E (where E is the field) and x should be a straight line. This was not found to be the case. If the field intensity at the end of the dark space be denoted by E_0, and that at any point in the dark space by E, the quantity $E - E_0$ appears to increase nearly proportionally to the square of the distance between that point and the end of the dark space, *i.e.* if d is the distance of the point considered from the kathode, d_0 the length of the dark space, $E - E_0 = k(d_0 - d)^2$. The value of E_0 was found to lie between 2300 and 4100 volts/cm. Although the value of k varies within a fairly wide range, the product kd_0D, D being the diam. of the tube, is practically constant, and hence may be used to estimate the field intensity in the Crookes' dark space in a narrow tube. The value of this constant is about 5·2. To get greater field strength just in front of the kathode d_0 must be increased and D be decreased. With the small tubes used, however, when the length of the dark space was increased, the end of the dark space became indistinct, and at last a sudden change occurred in the appearance of the dark space. The weak glow which formerly existed disappeared, and a glow as intense as that in the positive column replaced it. In this state of discharge no trace of the electric separation of the hydrogen lines could be observed. With a tube of diam. 1·5 mm. this sudden change occurred when the length of the dark space was increased above 2·5 mm. This max. length of the dark space increased with the diam. of the tube, but the numerical relation was not examined. Lo Surdo found that the dark space was independent of the strength of the current when the pressure was kept constant. The authors of the present paper, however, detected a certain increment in the length of the dark space when the current was increased. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

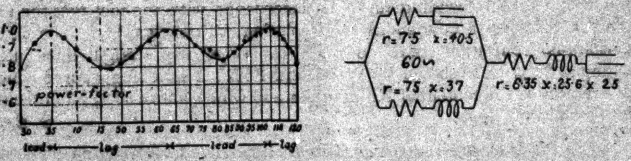
867. *Effect of Hydrogen on the Electric Resistivity of Carbon.* **T. Peczalski.** (Phys. Rev. 11. pp. 363–371, May; *erratum*, p. 508, June, 1918.)—A diagrammatic representation of the apparatus employed is given, also tables and curves of the results obtained. It is concluded that hydrogen apparently produces no effect on the resistivity of carbon at ordinary temperatures for pressures up to 33 atmos. The resistance of carbon increases considerably when the filament is heated to a high temperature in hydrogen. The resistance at room temperatures following such a heating in hydrogen shows a similar and more marked increase. Subsequent heating of the filament in vacuum to the same temperature produces the opposite effects. The effect is greater for the higher pressures than for the lower pressures. It appears that these changes obey an exponential law, and are about equal in magnitude in cases where the filaments are not injured appreciably by the processes involved. The changes in resistance, together with the giving up of gas on the heating in vacuum show that absorption of hydrogen by the carbon filament takes place. The ordinary absorption of gas by porous substances in which there is a purely mechanical entrance of the molecules of gas into the pores cannot explain the observed phenomenon. Gas thus mechanically absorbed disappears when the absorbing substance is placed in a vacuum, or when heated to moderate temperatures such as 800° C. According to measurements here recorded it is evident that only a portion, if any, of the gas is held thus mechanically. It may be reasonably supposed that at the high temperatures the gas enters the carbon, and that a solid solution of the carbon with hydrogen or of carbon with some hydrocarbon is formed: this solid solution will be stable at the given temperature and pressure. This means that at the high temperature the molecules possess velocities which, under a given pressure, are consistent with maintaining a solution of some specified concentration. When the temperature is suddenly greatly decreased the same solution may well still exist. When the filament is heated to the same high temperature under a pressure somewhat lower, a less concentrated solution may be expected. It may be noted that observations with metals show that the formation of a solid solution by the introduction of a small amount of some other substance, increases considerably the electrical resistivity of the metal. It is possible that some similar phenomena occur here. A. E. G.

868. *Thermoelectric Action with Dual Conduction of Electricity.* **E. H. Hall.** (Nat. Acad. Sci., Proc. 4. pp. 98–103, April, 1918).—In a previous paper [Abs. 704 (1918)] the author has discussed thermoelectric action in metals on the supposition of progressive motion of "free" electrons only. An extension is made in the present paper, conduction being supposed to be maintained partly by "free" electrons and partly by "associated" electrons, the latter passing directly from atomic union to atomic union. The free-electron pressure gradient acts on the free electrons only, but both types are acted upon by an established potential gradient. Thus, at the hot end of a detached metal bar the high electron-gas pressure will cause a constant procession of free electrons to the cold end. This will establish an excess of negative potential at the cold end, and the associated electrons will move from the cold to the hot end of the bar. The consequent slight reduction of electron mechanical pressure at this end induces continued passage of the electrons from the associated to the free type (evaporation, with absorption of heat), and at the cold end the small excess pressure will cause electrons to pass from the free to the associated class (condensation, with evolution of heat). The action is somewhat analogous to a steam heating system, the free electron movement corresponding to the stream of steam and the associated electron motion to the return flow of water. It is necessary to assume a specific attraction of metals for electrons, for in a bar of alloy varying in composition from pure α at one end to pure β at the other end there must be no progressive motion of either type. Again, in a bar of metal having a temperature gradient, and the free electron density increasing with the temperature, there must be a differential specific attraction tending to move electrons towards the cold end. Introducing these conceptions the author shows how the e.m.f. of a thermo-couple can be represented by an area on the P-V plane. The same result is obtained whether the hypothesis be made that the mechanical tendency is towards equality of pressure or towards thermal effusion equilibrium. L. L.

869. *A Galvanic Interrupter.* **W. Kasperowicz.** (Phys. Zeits. 19. pp. 187–188, May 1, 1918.)—A galvanic interrupter is described in which mercury is used as the conducting fluid medium, in place of the usual electrolytic fluid. A simple arrangement consists of two insulating vessels (made of porcelain, quartz, or glass), one of which slides easily in the other, and both filled with Hg. A small opening in the inner vessel allows contact, by means of a thin Hg thread, between the two Hg masses. A single vessel divided into two parts by an insulating partition will answer the same purpose. A glass or quartz U-tube, the bore at the bend of which is made very small, when filled with Hg is found particularly suitable for demonstration purposes. When such an interrupter is placed in circuit with a direct or alternating current the Hg thread is vaporised when the current is of suitable strength, and a small arc is formed, the current being thus lowered considerably or even broken. The Hg vapour condenses very quickly, the thread re-forms, and the current is again short-circuited. The process then commences once more. The current strength required depends upon the thickness and length of the Hg thread as well as upon its form; further, the rate of loss of heat is an important factor. A mercury thread 1 mm. in diam. and several mm. in length will, with suitable loss of heat, act as interrupter for a current of about 200 amps. It is possible also to construct a galvanic interrupter on the Wehnelt principle. A. E. G.

ALTERNATING CURRENTS AND MAGNETISM.

870. *Combination of Series and Parallel Resonance.* **H. L. Dodge.** (Iowa Acad. Sci., Proc. 24. pp. 189–200, 1917.)—In a circuit in which inductance and capacitance are in parallel the current becomes a minimum at resonance, lags for low frequencies and leads for high frequencies. The opposite occurs in a circuit in which the inductance and capacitance are in series. This suggests that by combining the two circuits identical values of current and power factor might be obtained at more than two frequencies. The author discusses this question with the help of hodographs showing the variation of the different vector quantities involved with the frequency, and gives the results obtained from experiments with different circuits, of which those illustrated in the Fig. are typical. He has succeeded in maintaining the power factor practically at unity for a range of frequency from 45 to 78 cycles and causing it to drop off rapidly outside this range. He discusses the influence of each of the components of the circuit on the results, and suggests that a study of such circuits may be of use in connection with the examination



of the phenomena due to the presence of harmonics in the wave-form and also in telephony in cases where an impedance is required to vary with frequency in a definite manner. W. H. G.

871. *Cause of Irreversibility of Nickel Steels.* **K. Honda** and **H. Takagi.** (Tôhoku Univ., Sci. Reports, 6. pp. 321–340, April, 1918. 16th Report of Alloys Research Inst.)—The irreversibility is not due to the carbon present in the steel, because the phenomenon is also found in the pure iron-nickel system. Further, those alloys which exhibit irreversibility always contain iron. Hence the effect is due to a property of iron as affected by nickel. According to Chevenard, it is due to the A3 transformation of iron as affected by the compound Fe_3Ni. The authors experimented on Ni steels of different compositions made by melting together known weights of iron and nickel, the ingots obtained being formed into cylinders 7 × 0·5 cm. In general, the critical point of a ferromagnetic substance is lowered by adding to it a non-magnetic or ferromagnetic substance; it is raised if the added substance has a higher critical point than the original substance and if the two form a solid solution. Thus, by adding to Ni an increasing amount of iron, the A2 point of Ni is steadily raised; and by adding to iron an increasing quantity of Ni, the A2 point of iron is lowered. When the proportion of added Ni is about 27 %, there is a minimum in the A2 point, which then lies a little below room temperature. With further addition of nickel, the A2 point rises, and reaches a maximum with 70 % Ni. It is concluded that the A3 transformation is inconspicuous above 25 % Ni, and at 70 % Ni completely vanishes. With regard to thermal expansion, Chevenard's curves show that Ni-steels contract while passing through a certain range of rising temperature. Thus invar (35 % Ni) changes from contraction to expansion at room temperature. This remarkable property of invar is obtained by bringing the temperature of minimum elongation, or that of the A3 transformation to the vicinity of room temperature. There is no need to assume, as is done by Guillaume, Chevenard, and others, that the property of invar is due to the presence of the compound Fe_3Ni. The peculiar form of the critical point-concentration curve is explained by means of Honda's theory of ferromagnetism. The magnetisation-concentration curve in a very strong field tends to a straight line or to a slightly bending curve, in accordance with the fact that the two components form a continuous solid solution with each other. The Curie constant-concentration curve does not consist of two straight lines intersecting at 35 % Ni as shown by Weiss and Foëx; it is a single curve which falls rapidly as the content of Ni increases and which, above 30 % Ni descends with a constant slope. G. E. A.

872. *The Magnetic Analysis of Carbides in Steels.* **T. Ishiwara.** (Tôhoku Univ., Sci. Reports, 6. pp. 285–294, April, 1918. 15th Report of Alloys Research Inst.)—K. Honda and T. Murakami employing a magnetometric method have recently [Abs. 1026 (1917)] shown that the magnetic transformations of cementite and the double carbide of iron and tungsten take place at 215° C. and 400° C. respectively, and that at higher temperatures these carbides decompose into their constitutents. To investigate the matter more closely the author uses a torsion method for measuring the susceptibility. In addition to the carbides isolated electrolytically from different C steels, those from Mn and Cr steels, as well as from high-speed tool steels, were studied. The magnetising fields varied from 120 to 2012 gauss and the results are represented graphically by a series of susceptibility-temperature curves. The chief conclusions drawn are: (1) The sudden rise of susceptibility between 650° and 730° shows the decomposition of the carbides into their components. (2) The residue shows by the magnetic transformation at 580°, the presence of magnetite produced by oxidation of cementite. (3) Natural magnetite and chemically prepared magnetic oxide are differentiated by their critical points, 580° and 510° respectively. (4) The separation of cementite from the solid solution of a eutectoid steel begins at about 130° and nearly ends at 360°. The three ranges of temperature, 15–130°, 130°–360°, 360°–600°, correspond to martensite, troostite, and sorbite respectively. The end point of the solid solution, 360°, corresponds to osmondite. Magnetically considered, martensite is a solid solution of carbide in γ-iron. Troostite includes the stages corresponding to different degrees of separation of cementite as colloidal particles. Sorbite has the same susceptibility as pearlite. (5) The residue from the quenched specimen contains initially a small quantity of cementite; the amount increases with tempering temperature, till it reaches 360°. These residues are very reactive and take fire in the atmosphere. The tendency to oxidation decreases with the increase of tempering temperature. (6) The double carbide of Fe and Mn is magnetic; by heating the residue to 400°, magnetite is formed by oxidation. By further heating, it decomposes into cementite, free iron, and magnetic oxides. The double carbide of Fe and W is magnetic and decomposes at high temperatures. The residues from Cr steel and high-speed tool steel are paramagnetic. L. L.

873. *Magnetograph Records at Theodosia, Crimea, during the Total Solar Eclipse of August* 21, 1914. **L. Palazzo.** (Terrest. Magn. 23. pp. 29–31, March, 1918.)—A party of Italian scientists, of which the writer was a member, went to Theodosia, Crimea, in the belt of totality. Astronomical, spectroscopic, and photographic observations on the celestial phenomenon were to be made, as well as various geophysical investigations allied with the occurrence of the eclipse. The scheme of work was planned to embrace pyrheliometric, meteorological and magnetic observations, measures of the penetrating radiation, and records of temperature on the soil surface. But the principal work proposed was properly the magnetic one, viz., that of registering the variations of the three magnetic elements during the eclipse. The magnetograph was working day and night from Aug. 16 to 28. Thus the average solar-diurnal course of the three magnetic elements D, H, Z could be determined on several days immediately before and after, as well as on the very day of the eclipse. This average daily change is represented in a table for which reference should be made to the original paper. In the report the writer concludes that a small magnetic effect referable to the eclipse has manifested itself, especially in the declination curve. The principal disturbance occurred almost 6 minutes before totality, and its range may be estimated at about 0·85′ (the north end of the declination needle being deflected towards east by a disturbing force of $=5{\cdot}7\gamma$).

The absolute values of the magnetic elements were also determined, with the field-magnetometer and the dip-circle, on Aug. 26 and 27, namely:

$$D=+1^\circ 02'{\cdot}7,\quad I=+59^\circ 28'{\cdot}5,\quad H=23218\gamma;$$

The total intensity and its components are therefore:

$$T=45712\gamma,\quad X=+23214\gamma,\quad Y=+423\gamma,\quad Z=+39377\gamma.$$

Hence is also calculated the so-called "local magnetic constant" at Theodosia: $G=0{\cdot}30442$ c.g.s.

All these apply, of course, to the epoch 1914·65. E. O. W.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

874. *Third Kind of Sulphur Molecule.* **V. A. H. W. Aten.** (K. Akad. Amsterdam, Proc. 20. 6. pp. 824–830, 1918.)—In continuation of previous experiments [compare Abs. 272 (1918)] the equilibrium $S_\lambda \rightleftarrows S_\pi$ in toluene solution has been determined at 140°, 150°, and 160°. By means of theoretical considerations, which are based on previous practical measurements, it is shown that in sulphur chloride solution at 100°, in a mixture containing 50 at. % of total sulphur, the equilibrium mixture contains about 25 at. % of S_π. In toluene the equilibrium mixture at 140° contains not quite 5 at. % of S_π, which is of about the same order of magnitude as in carbon disulphide as solvent. T. S. P.

875. *Some Properties of Fog.* **W. D. Bancroft.** (J. Phys. Chem. 22. pp. 309–336, May, 1918.)—This paper, which deals with the principal investigations into the properties of fogs that have been carried out in recent years, starts with a definition of "fog" and describes the experimental methods of producing it. The effect of suspended dust particles is noted. Ozonised air is very active and oxygen, hydrogen, and nitrogen become active when they are heated. Helmholtz found that the vapours of H_2SO_4, HCl, and H_2SO_3 act as nuclei, and Helmholtz and Richarz have advanced the view that condensation occurs frequently during chemical reactions even though the reacting substances and reaction products do not act as nuclei. They conclude that the reactions pass through an intermediate stage in which ions are formed, and that these ions act as nuclei. The experiments of Haber and Just prove conclusively that electrons are emitted during some chemical reactions, but they do not prove at all that there is always an intermediate formation of ions in every chemical reaction. The experiments of C. T. R. Wilson on the condensation of water-vapour have rendered it extremely probable that this condensation occurs around electrical nuclei of some sort.

While fog usually consists of condensed water there are conditions under which we have special types occurring. Thus Frankland describes what he calls "dry fog." It is suggested that the existence of "dry fog" may be due to impurities. From manufactories and domestic fires vast aggregate quantities of coal-tar and paraffin oil are daily distilled into the atmosphere, and condensing upon, or attaching themselves to, the watery spherules of fog, must of necessity coat these with an oily film, which would, in all probability, retard the evaporation of the water and the consequent saturation of the interstitial air. There is also the possibility of "dryness" being due to a lowering of the vapour pressure of the drops by the dissolving in them of SO_2, H_2SO_4, etc. Supercooled fogs also occur at times. The colours due to fogs, such as are seen in "fog-bows" and the glories or coronæ round sun or moon, are discussed. The studies by Barus go far to show that the coloured clouds and coloured suns are truly interference phenomena, not necessarily interferences by diffraction. Rain appears to begin when the drops reach a diameter of 0·04 mm., and according to Lenard the max. size is reached at 5·5 mm. diam. and these large drops have a practically constant rate of fall of about 8 m. per sec. Based on these facts Simpson has developed a theory in regard to thunderstorms. It is exceedingly probable that during thunderstorms ascending currents much greater than 8 m. per sec. come into play, and these must, therefore, hold a considerable quantity of water in suspension.

The water will be constantly going through the process of growing from small drops to large drops, only to be broken up into small drops again. If, therefore, the breaking up of a large drop is accompanied by a separation of electricity, thunderstorm electricity might owe its origin to such an effect.
A. E. G.

876. *Structure of Tungsten Steels and its Change under Heat Treatment.* **K. Honda** and **T. Murakami.** (Tôhoku Univ., Sci. Reports, 6. pp. 235–283, April, 1918. 18th Report of Alloys Research Inst.)—A continuation and correction of earlier work on magnet steels. Steels containing from 0·28 to 30 % tungsten have been examined. The constituents which may be present in these steels are: iron, iron tungstide (Fe_2W), iron carbide (Fe_3C), tungsten carbide (WC), and a double carbide ($4Fe_3C . WC$). Iron tungstide and tungsten carbide are non-magnetic. The presence of Fe_3C or the double carbide in a steel may be determined by the fact that each possesses a magnetic critical point, Fe_3C about 215° C. and $4Fe_3C . WC$ at about 400° C. The steels of varied tungsten and carbon content were quenched from different temperatures and then subjected to magnetic analysis. In the normal state the double carbide is present, which at temperatures above the A*c*1 point dissociates with its component carbides. At about 900° C. the following reaction commences: $WC + 5Fe \longrightarrow Fe_2W + Fe_3C$, and above 1000° C. is complete. It is exceedingly difficult to reproduce the double carbide on cooling, but if the steel is reheated to just above A*c*1 and then cooled normally the compound is re-formed. A first approximation to the thermal-equilibrium diagram for the iron-tungsten alloys is published, which points clearly to the existence of the compound Fe_2W, the presence of which in an alloy may be determined by the fact that it is blackened by boiling sodium picrate solution.

Sixty-three micrographs are included of iron-tungsten alloys. F. C. T.

877. *Rates of Cooling for Tempering Carbon Steels.* **P. Chevenard.** (Comptes Rendus, 166. pp. 682–685, April 29, 1918.)—According to Portevin and Garvin, Dejean and the author [Abs. 1191, 1192, 1318 (1917)] there is, when a steel has been heated to a temperature θ_c (higher than the point A*c*), a certain critical rate of cooling V_0; when this rate is exceeded, part of the transformation A*r*2 takes place at a lower temperature, and martensite is produced. As in the previous paper the author heats pure steels containing 0·2 to 0·8 % C to redness and cools them at different rates in an indifferent atmosphere, observing the dilatation of the wire specimen to indicate any change in the transformation A*r*2. The four atmospheres used consist of hydrogen, $\frac{2}{3}$ H + $\frac{1}{3}$ nitrogen, $\frac{1}{3}$ H + $\frac{2}{3}$ N, nitrogen; as the nitrogen increases, the rate of cooling falls off very rapidly at first, then slowly—not according to the rule of mixtures. In a series of experiments made in one of these atmospheres θ_c is raised in steps and A*r*1 and A*r*2 are photographically registered; from the curves thus obtained the appearance of martensite (in the place of troostite) can be followed, and the V_0 required for tempering can be expressed as function of the carbon percentage. As this percentage decreases, the necessary V_0 increases, slowly at first, but very rapidly when the carbon percentage falls below 0·5; the impossibility of lowering the transformation-point of pure iron simply by cooling can thus be understood. As regards tempering, an insufficient rate of cooling can, in a measure, be compensated for by raising the temperature of reheating; but this compensation becomes less effective in low-carbon steels. H. B.

878. *The Macrostructure of Steel.* **A. Portevin and V. Bernard.** (Rev. de Mét. 15. pp. 273–280, May–June, 1918.)—The macrostructure of steel may be clearly developed by etching the sample with Stead's reagent as modified by le Chatelier and subsequently repolishing lightly. The structure so obtained is the original dendritic one produced during the freezing out from the liquid state and retained as a result of inequalities in the phosphorus, etc., contents. An estimation of the amount of forging which the steel has received may be made by noting the extent of the deformation of the dendrites in three planes at right angles to each other. The replacement of the elongated crystallites at the surface of a casting by equiaxed crystals in the interior is clearly shown. No commercial heat-treatment appreciably influences the macrostructure on account of the low rate of diffusion of the phosphorus. Reheating a steel to 900° C. for 3 days produces some obliteration of this structure; it disappears completely when the period of treatment is doubled. F. C. T.

879. *Energy Change in Photochemical Processes in Gases.* IV. *Influence of Wave-length and Pressure upon Photochemical Organisation.* **E. Warburg.** (Preuss. Akad. Wiss. Berlin, Ber. pp. 872–885, 1914. From the Physikal-Technn. Reichsanstalt.)—The continued researches [see Abs. 1628 (1911), 950 (1912), 1557 (1913)] were partly undertaken for the purpose of testing Einstein's law of photochemical equivalence, and of distinguishing between primary and secondary photochemical reactions, in which only the final products can be determined. According to Einstein [Abs. 1046 and 1689 (1912)] the decomposition of 1 gm. equivalent by a photochemical process requires an absorption of the energy $Nh\nu$, where ν is the frequency of the absorbed energy (not the radiation frequency of the absorbent); the law is applicable only within the validity range of Wien's law, and when the decomposition is exclusively a thermal effect. When radiation of wave-length λ (in μ) is absorbed, the primarily decomposed mass of the photolyte in molecules per gm.-cal. absorbed is $p = \lambda/1{\cdot}987c$, where $c = 14{,}300$. The author assumes that the subsequent secondary reactions do not depend upon the radiation, and he designates the amount of the final product corresponding to p by ϕ. In order to calculate ϕ from p, assumptions have to be made as to the reactions. In the case of the ammonia NH_3 decomposition, ϕ would be equal to p, if there were only decomposition and no union of the N and H to NH_3; but for $\lambda = 0{\cdot}209\,\mu$, ϕ was found $0{\cdot}172 \times 10^{-5}$, whilst $p = 0{\cdot}735 \times 10^{-5}$; in that case then either Einstein's law would be inapplicable, or there would be re-formation of ammonia. In ozonisation the primary process is $O_2 = O + O$, the ozone formation itself $2O + O_2 = 2O_3$ and possibly $O + O = O_2$ being secondary. In the experiments the ϕ and p were found to be in fair agreement for $\lambda = 0{\cdot}209\,\mu$ and pressure $P = 125$ kg./cm.²; for $\lambda = 0{\cdot}253\,\mu$ the agreement was not satisfactory. At $P = 125$ kg. the ozone yield was 55 % of the theoretical, at 300 kg. only 29 %; thus the yields decreased as the pressure was raised—a fact for which Einstein's law does not account. As regards the wave-length $\lambda = 0{\cdot}209$ gave at 300 kg. a yield of 88 %, and $\lambda = 0{\cdot}253$ only of 53 %. According to Einstein, the author points out the p values should increase with increasing λ to a limit and then vanish. This is improbable, and he suggests that the assumption (implied in the law) that all the absorbing molecules are decomposed, may have to be abandoned.

V. *Absorption of Ultra-violet Radiation by Oxygen.* (*Ibid.* pp. 230-242, 1915.)—The experiments are made for $\lambda = 0{\cdot}209$ and $0{\cdot}253$ and the pressure range 30 to 400 kg./cm.². Considerable deviation from the law of Beer is observed, the molecular absorptive power of oxygen being found to increase strongly with increasing pressure. The deviations are the greater the smaller the pressure, and greater also for the shorter than for the longer waves. The absorptive power is probably influenced by neighbouring molecules in the sense suggested by K. Ångström in 1908; the author deduces a formula for the absorptive power up to 400 kg./cm.^{2}. It is in accord with this view that mixtures of oxygen with an indifferent, non-absorbing gas (nitrogen), show a smaller deviation from Beer's law than pure oxygen; this is shown experimentally and theoretically. The specific ozonisation (the number of molecules of ozone per gm.-cal. absorbed) is independent of the oxygen percentage.

VI. *Photolysis of Hydrogen Bromide.* (*Ibid.* pp. 314–329, 1916.)—Hydrogen, purified of oxygen by being passed over glowing copper in an electric furnace, or nitrogen is passed through an aqueous solution of HBr, the dried gas stream cooled to —77° C. and exposed to the ultra-violet rays $\lambda = 0{\cdot}209$ from a zinc arc; the gas then enters an alkaline solution of potassium iodide, which is decomposed by the bromine liberated. This quantity and the partial pressure of the HBr are determined. The primary reaction would be $BrH = \frac{1}{2}(Br_2 + H_2)$, the secondary reactions $H + H = H_2$; $Br + Br = Br_2$; $H + BrH = H_2 + Br$; $Br + BrH = Br_2 + H$. The partial pressure of the HBr (26 to 290 mm.), the gas flow (above 20 cm.^{3} per min.) and the nature of the indifferent gas (H or N) did not influence the results. The yield of the reaction, *i.e.* the fraction of the absorbed radiation which is converted into chemical energy, is found to be S = 18·5 %, the theoretical yield being 17·8 %; in the calculations of the primary and secondary reactions the calories merely spent in heating the compounds are counted as wasted. The yield is in general the greater the smaller the heat of formation of the secondary processes.

VII. *Photolysis of Hydrogen Iodide.* (*Ibid.* pp. 300–317, 1918.)—The experiments with HI are still more instructive than those with HBr, because the absorption in the case of the hydriodic acid extends into the range of greater wave-lengths, and because the secondary reactions can better be observed. On the other hand, the experimental difficulties are much greater. According to Lemoine (1877) gaseous HI kept constant in the dark for over a year, but was decomposed by sunlight to the extent of 24 % in 10 days, and 80 % in 82 days; when heated in the dark to 265°, the decomposition was 2 % in 30 days; in the presence of air (oxygen), however, both gaseous and aqueous HI were soon decomposed even in the dark. Similar observations were made by Bodenstein (1897) and by Coehn and Stuckardt (Göttingen Nachr. p. 722, 1916), who studied the influence of radiations from 0·220 to 0·300 μ. The author's apparatus is of the Bodenstein type, like that used in VI; for the reasons mentioned, it was found that the current of hydrogen and HI gas must not come in contact with any wet glass walls: the apparatus had finally to be made of quartz glass, the use of phosphorus pentoxide altogether to be avoided, and the HI to be prepared after Bodenstein. In his method, which proved much more convenient, moreover, than the usual method, iodine vapour and hydrogen are brought into contact with finely-divided Pt at 600°; even then there was danger of some impurity apparently from the platinum-asbestos which decomposed the HI, and a correction had to be made though the asbestos was first heated for 8 hours. The exposure to the radiations was made for 600 or 900 secs. at temperatures between —52° and —70° at which the vapour pressure of saturated HI ranges from 348 down to 118 mm. of mercury. The radiation was by sparks between electrodes of Zn or of Mg;

the zinc lines used were $\lambda = 0{\cdot}203$, $0{\cdot}206$, $0{\cdot}209$, $0{\cdot}210$, $0{\cdot}214\,\mu$, the intensities of which were determined by Pflüger, the group of zinc lines $0{\cdot}241$ to $0{\cdot}261\,\mu$, and the Mg lines $0{\cdot}280$, $0{\cdot}285$, $0{\cdot}293\,\mu$. The spark-gap had to be made wide, however, and the sparks were not constant as to their starting-points on the electrodes; this is considered the main source of errors. The primary reaction is $2HI = H_2 + I_2$, and therefore ϕ equal $2p$; of the secondary reactions $H + IH = H_2 + I$ is considered the most likely. On this assumption the ϕ and $2p$ agree very well, and the max. wave-length capable of decomposing the hydrides would increase the order HCl (hypothetical), HBr, HI. The maximum λ, which can decompose HI, would be $0{\cdot}440\,\mu$, and the longest waves tried ($0{\cdot}2824\,\mu$) would give $1{\cdot}56$ times the required energy. For the first class of photochemical reactions, in which the quantum of effective wave-length is sufficient for the direct decomposition of the absorbing molecule, the primary process can be calculated from the photochemical equivalent, provided some hypotheses as to the secondary reactions can be made. For the reactions of the second class, in which the quantum does not suffice for the direct decomposition, the Einstein law fails, since not all the molecules will be decomposed. H. B.

880. *Electrical Endosmose.* II. **T. R. Briggs, H. S. Bennett, and H. L. Pierson.** (J. Phys. Chem. 22. pp. 256–272, April, 1918.)—An improved form of electro-osmometer is described, in which the rate of flow of liquid through the diaphragm is measured by observing the speed with which an air-bubble moves along a calibrated tube in hydrostatic connection with the electrolyte surrounding each electrode. The diaphragms used consisted of glass powder, asbestos, cellulose, and crystolon (CSi) and alundum; the liquids used were distilled water, dilute NaOH or dilute HCl, and solutions of various copper salts. It was shown that the rate of electrical endosmose is proportional directly to the applied potential, other conditions being kept constant. It increases with rise in temperature; it is not exactly proportional to the fluidity of the liquid, but increases slightly less rapidly than the fluidity does with rising temperature. For a given diaphragm and a given liquid the results of experiment confirm the equation $V = hED/\eta$, where V is the volume of liquid transported through the diaphragm in unit time; E the e.m.f., D the dielectric constant, and η the viscosity. Perrin's work on the reversal effect with dilute solutions of acid and alkali was repeated and confirmed. The investigations with copper salts showed that solutions of copper acetate, nitrate, and chloride, flow to the anode, indicating that the copper ion is adsorbed more than the acetate, nitrate, or chloride ion. With copper sulphate reversal occurs to the kathode, in 0·1 and 0·2 normal solutions, showing that the sulphate ion is more strongly adsorbed than the copper ion at ordinary concentrations, that is, concentrations of 0·1 normal upwards. Experiments with various dyes, both basic and acid, showed that there is a connection between contact electrification and the process of dyeing. [Compare Abs. 700 (1917).] T. S. P.

881. *Abnormality of Strong Electrolytes. I. Electrical Conductivity of Aqueous Salt Solutions.* **J. C. Ghosh.** (Chem. Soc. J., Trans. 113. pp. 449–458, May, 1918.)—According to the author, the fundamental suggestion of Arrhenius, which postulates the coexistence of undissociated molecules and ions in solution, is probably not valid. It is assumed, instead, that in solutions of strong electrolytes only ions are present, the attractive forces between the ions being governed only by the physical laws of electrostatic attraction. On

the basis of this simple assumption a quantitative interpretation of the increase of molecular conductivity with dilution is given. A salt solution where only ions are present is taken to be perfectly analogous to a gaseous system. Owing to the electrical attraction between oppositely charged ions a field of force exists in the interior of the salt solution, the potential of which may be represented by A; that is, A is the work done when the ions constituting a gm.-molecule go beyond one another's sphere of attraction. The distribution of velocities of the ions, which are endowed with kinetic energy of translation, is governed by Maxwell's law, and only those ions will be free, that is, capable of escaping from the electrical field inside the solution, which have a kinetic energy greater than the work to be done in so escaping. The number of free ions is thus the fraction of the total number of ions having a velocity greater than the critical velocity v_0, where $1/2mv_0^2 = A/nN$. N is Avogadro's number, n the number of ions into which a molecule dissociates, and A/nN is therefore the work to be done by each ion before it can escape. The number of free ions is then deduced to be $nNe^{-A/nRT}$, and this will be the number of free conducting ions at a given dilution. At infinite dilution A is zero, since the ions are outside one another's sphere of attraction, and therefore the number of conducting ions is nN. It follows that $\mu_v/\mu_\infty = nNe^{-A/nRT}/nN = e^{-A/nRT}$, that is, $A = nRT \log_e(\mu_\infty/\mu_v)$. In order to find the value of A it is necessary to make further assumptions. In the first place it is assumed that the marshalling of the ions of a salt in a state of solution is analogous to the arrangement of its atoms in the crystalline structure. If, further, it is assumed that the component ions of a salt-molecule form a completely saturated electrical doublet, the work necessary for separating the ions (on electrolysis) is the electrical work done in moving the ions constituting a doublet from their fixed mean distance in the solution to an infinite distance apart. For a binary electrolyte like potassium chloride this work (A) is given by the expression E^2/Dr, where E is the charge on each ion, D the dielectric constant of water, and r the distance between the oppositely charged ions at the given dilution. For salts of the type of barium chloride the work is $3E^2/Dr$, and of the type of magnesium sulphate $4E^2/Dr$. In these formulæ E and D are known, and if r can be found, the value of A is given, and hence μ_∞/μ_v can be calculated. The value of r can be calculated by making use of Bragg's measurements on crystals, since it is assumed that the structure of the salt in solution is similar to the crystalline structure. Thus in the cubic crystal of potassium chloride $r = \sqrt[3]{(V/2N)}$, where V is the number of cm.³ containing a gm.-molecule, there being 2N ions in the total volume (V) occupied by 2N unit cubes. It follows that $A = NE^2/Dr$ for the gm.-molecule, and this $= NE^2 \sqrt[3]{2N}/D\sqrt[3]{V}$, which, as above, is equal to $2RT \log_e \mu_\infty/\mu_v$, since $n = 2$ for potassium chloride. In the expression $2RT \log_e \mu_\infty/\mu_v = NE^2 \sqrt[3]{2N}/D\sqrt[3]{V}$, all the quantities are known with the exception of μ_∞/μ_v, which can therefore be calculated. μ_∞ can be determined by experiment, and hence μ_v can be calculated. Similar expressions can be deduced for electrolytes similar to barium chloride and to magnesium sulphate. For binary electrolytes the expressions have been tested in the cases of KCl, NaCl, LiCl, CsCl, NH_4Cl, KBr, KI, KNO_3, $NaNO_3$, and $C_2H_3O_2K$. The difference between the observed and the calculated values is rarely greater than 1 %, as illustrated by the following figures for KCl, which hold for 18°:—

μ_∞ (calc. from μ_{100})		$v = 10$	20	100	1000	5000 litres
132·2	μ_v calc.	111·7	115·7	122·5	127·7	129·2
	μ_v obs.	112·0	115·9	122·5	127·6	129·1

A similarly good agreement was observed in the cases of $BaCl_2$, $SrCl_2$, and $CaCl_2$. With $MgSO_4$, $ZnSO_4$, and $CuSO_4$ the agreement was not so good at high dilutions ($V=1000$), probably because of the observed conductivity values being affected by hydrolysis.

If the variation of the dielectric constant (D) of the solvent with temperature is known, the above expression should give the value of μ_v/μ_∞ for any particular temperature. It is shown in the case of KCl that equally good results are obtained at 100° as at 18°, that is, the diminution of the ratio μ_v/μ_∞ with increase in temperature is quantitatively explained.

The case of weak electrolytes, which are invariably either acids or bases, has still to be dealt with. It is pointed out that the abnormally high conductivity of hydrogen and hydroxyl ions leaves no room for doubt that here there is a chemical interaction between solvent and solute molecules. Ostwald's dissociation constant is probably related in some way to the constant of these specific chemical reactions. T. S. P.

882. *Passivity of Chromium.* II. **A. H. W. Aten.** (K. Akad. Amsterdam, Proc. 20. 8. pp. 1119–1134, 1918.)—In continuation of a previous investigation [Abs. 814 (1918)], details are given of a large number of experiments on the potential shown by chromium under anodic and kathodic polarisation; in the previous investigation the Cr was not subject to an electric current when immersed in a solution. An adequate account of the experiments would be very lengthy, so only the main conclusions can be given. With a sufficiently high strength of current (1 milliamp. was the lowest used), electrolytic chromium in chromous sulphate solution becomes passive under anodic polarisation. After breaking the current the potential of the electrode becomes more negative than before the polarisation. As the strength of the polarising current is gradually increased the potential at first assumes a too positive value, which slowly decreases with further increase in current strength, this being explained as being due to activation which takes place during the polarisation. When the current strength is gradually diminished the above phenomena are reversed. The more vigorously the electrode is polarised the greater is the activation during the anodic polarisation, as shown by the retrogression of the potential with increase in current.

Chromium prepared by Goldschmidt's thermite method, which has been made active by treatment with molten $ZnCl_2$ or a mixture of NaCl and KCl, can be anodically polarised in a solution of KCl without becoming passive. The strength of current which the Cr can thus resist without passivification is greater when the current is gradually increased than when it is rapidly increased. When the Cr has been previously subjected to kathodic polarisation it requires a lesser anodic current to make it passive than otherwise would be the case. Thermite chromium which has been made passive by anodic polarisation in a solution of KCl becomes active on heating the solution, even during the passage of the current. On cooling it still remains active if the current is not too strong. When the Cr cools down in the solution without being anodically polarised at the same time, the activity which it retains on cooling is less than when the current passes during cooling.

The increase in activity during anodic polarisation mentioned above is considered to be caused by a change in the metal surface. Explanations of the phenomena are to be given in a later paper. T. S. P.